

# **EXHIBIT F**

## Lead in the Lake Tahoe Environment

*Prepared for*

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September 9, 2024

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## EXECUTIVE SUMMARY

This report evaluates the sources and quantities of geogenic and anthropogenic lead released into Lake Tahoe, in light of the allegations in the complaint filed by the California Sportfishing Protection Alliance (CSPA), which alleges that there are approximately 7.8 miles of lead-clad telecom cable in Lake Tahoe. This report also evaluates the impact of these non-cable sources of lead on water and sediment quality in the lake.

Lake Tahoe is an alpine lake with circumneutral water, low suspended solids, and relatively little shallow littoral area along the shore of the lake. As lead is released to the lake, these characteristics facilitate the removal of lead from the water column. Based on studies of Lake Tahoe sediments, the lake receives approximately 700 kg of lead loading annually from natural sources, including water runoff from minerals in rock and groundwater inflow. Sediment studies also demonstrate that anthropogenic sources contribute thousands of kilograms each year to Lake Tahoe. These sources include urban runoff, historical aerial deposition from leaded gasoline use, and other lead uses in the urban and aquatic environments. Lead loading from anthropogenic sources has increased with urban development and is a major contributor of lead to the lake. In addition, fishing, boating, and hunting activities contribute hundreds of kilograms of lead to the lake each year. Although the complaint does not quantify any estimated releases of lead from the telecom cables, based on my review of relevant expert analyses, I conclude that any such release would be negligible compared with the typical annual releases of lead to the lake from non-cable sources known to contribute to lead loading in the lake.

Despite the natural and anthropogenic inputs to the lake, the concentration of lead in Lake Tahoe water is very low (less than 1  $\mu\text{g}/\text{L}$ ), and below all relevant water quality standards. This low concentration results from the natural processes in the lake that bind lead to sediment and other particles that settle out, removing the lead from the water column. As a result, the vast majority of lead in the lake is bound in fine sediments that settle to the deep lake bottom. These processes limit any impact of lead releases, whether natural or anthropogenic, on water quality in the lake.

## SUMMARY OF OPINIONS

1. Lake Tahoe is an alpine lake with circumneutral water, low suspended solids, and relatively little shallow littoral area along the lake shore. This setting does not favor retention of dissolved or suspended lead in the water column of the lake.
2. Lake Tahoe receives approximately 700 kg of lead loading annually from natural sources, including surface water runoff from minerals in rock and groundwater inflow.
3. Anthropogenic sources contribute thousands of kilograms each year to Lake Tahoe. These sources include urban runoff, historical aerial deposition from leaded gasoline use, and other lead uses in the urban and aquatic environment. This lead loading has increased with the urban development around the lake and is a major contributor of lead in the lake. In addition, fishing, boating, and hunting are additional sources of lead to Lake Tahoe.
4. Despite the natural and anthropogenic inputs to the lake, the concentration of lead in Lake Tahoe waters is very low (less than 1  $\mu\text{g}/\text{L}$ ), and below all relevant water quality standards, as a result of the natural processes in the lake that remove lead from the water column.
5. In the Lake Tahoe system, the vast majority of lead in the lake is bound in fine sediments. These sediments are removed from the water column and settle to the deep lake bottom.
6. The impact of lead-bearing cables assessed by others shows that the lead loading from cables is negligible compared to the other anthropogenic sources of lead to Lake Tahoe.

## 1 BACKGROUND

### 1.1 RETENTION

I have been retained by Paul Hastings LLP, which is representing Pacific Bell Telephone Company, to evaluate the sources and distribution of lead in Lake Tahoe. My qualifications, compensation, and prior testimony experience are described in Section 4 and Appendix A of this report.

### 1.2 LOCATION

Lake Tahoe is on the California-Nevada border on the eastern slope of the Sierra Nevada Mountains (Figure 1). The lake occupies much of the area of the drainage basin in which it sits, with a surface area of 495 km<sup>2</sup>. The drainage area that feeds Lake Tahoe is 1,311 km<sup>2</sup>, so that the lake comprises approximately 38 percent of the total drainage basin (Thodal 1997). The geology surrounding and underlying the lake is generally igneous intrusive and volcanic rocks, overlain by more recent glacial deposits and other overlying alluvium (Simon 2008). The lake is one of the deepest lakes in North America at 1,645 ft. The shallow, nearshore area is relatively narrow, with a steep drop off from the shallow band of littoral waters in the lake to the deep waters in the center of the lake, as shown in Figure 2.

The largest of the rivers flowing into the lake is the Upper Truckee River, which enters the lake in the town of South Lake Tahoe, California, with an average flow of 232 ft<sup>3</sup>/s (USGS 2024). The water from the lake exits to the Truckee River after passing across the Lake Tahoe Dam, which controls the water level of the lake. The average water flow to the Truckee River is 246 ft<sup>3</sup>/s (USGS 2024). Approximately 75 percent of the Lake Tahoe Basin is U.S. National Forest land.

As the lake consists of a large portion of the watershed that drains it, and much of the area around the lake is rocky with little soil development, relatively little sediment flows into the lake compared to most water bodies. This low sediment load results in little suspended sediment in the lake and the lake's famously clear water. However, the lake's clarity has been decreasing since the 1960s because of increased loading of fine-grained sediments and nutrient production (Simon 2008).

#### 1.2.1 Urban Development

Lake Tahoe is a popular destination for recreation, tourism, boating, and skiing. The lake basin has about 54,000 permanent residents and receives about 2 million unique visitors, resulting in 13 million visitor days per year in the region (Lake Tahoe Destination Stewardship Planning Team 2023). The population is dispersed around the lakeshore, with the primary towns being South Lake Tahoe on the southern shore, and Incline Village, Kings Beach, and Tahoe City on

the northern shore. One large development in South Lake Tahoe is the Tahoe Keys marina, which was constructed in the Upper Truckee River Marsh in the 1960s and is at the inlet of the Upper Truckee River as it enters the lake. The marsh serves as a natural filter for water entering the lake. Construction of the marina destroyed about half of the marsh, and the Upper Truckee River was channelized along one side of the marina, increasing the amount of sediment entering the lake. The marina brought more development and boat traffic to South Lake Tahoe. Also, during the 1960s, large high-rise casino hotels were constructed in the area adjacent to the city of South Lake Tahoe in Stateline, Nevada (Furgurson 1992).

During the development and use of the Lake Tahoe region as a resort destination over the past 100 years, the surrounding built area has been a source of urban contamination and resulting discharges to the lake. Because urban development leads to formation of urban-derived contaminants, including lead (Mahler et al. 2006), loading of these contaminants to Lake Tahoe sediment has increased as development has increased.

## 1.3 CHEMISTRY OF LEAD

The primary topic of this report is how lead in all of its chemical forms impacts Lake Tahoe. This section lays out the fundamental chemistry and uses of lead as background for further analysis.

### 1.3.1 Lead Abundance

Lead is a metal that is naturally present in soils and rocks, with natural lead concentrations in soils ranging from 2 to 200 mg/kg (Lindsay 1979). Locations that have naturally higher lead are spread throughout the country and are often associated with sulfide-based metal mineralization (Kabata-Pendias and Pendias 2010). The U.S. Geological Survey (USGS) has mapped its estimate of lead concentrations in soils across the United States, and it estimates that the Lake Tahoe area falls into the 70th to 80th percentile of soil concentrations, with average soil concentrations between 22.3 and 25.9 mg/kg<sup>1</sup> (Figure 3).

### 1.3.2 Lead Properties

The physical and chemical properties of lead result in it being used in a variety of common applications. Lead metal is malleable, is dense, and has a low melting point. Lead metal is environmentally stable and does not oxidize rapidly, even under conditions that are normally corrosive for other metals, such as acidic conditions and high salinity. The environmental stability of lead salts and the strong coloration of these compounds made it a favored ingredient in paints. Lead's density and interaction with glass made it a useful additive and key

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<sup>1</sup> Note that these are average concentrations, and higher and lower concentrations are expected.

to making fine crystal. Also, the unique organic chemistry of ethyl-lead compounds makes them useful octane enhancers in gasoline.

### 1.3.3 Lead Uses

The versatile properties of lead means that it is used in many settings from which it can be released into the environment. Lead's high density and malleability make it ideal to be used as weights for fishing tackle, in balancing tires, and in ammunition, as an easy to shape, dense material is desired. Its electrochemical properties facilitate its use in batteries. The environmental stability of lead metal and its malleability allows it to be used for piping sulfuric acid in industrial operations as well as for flashing on roofs, boat hulls, plumbing pipes, and coating for telecommunications and electrical cables. Lead has historically been used in solder to fasten copper wires and electronics because of its low melting point, malleability, and environmental stability.

One of the largest historical uses of lead is in lead paint and coatings. Lead minerals tend not to "chalk" and they inhibit the growth of organisms on the paint. Red lead ( $Pb_3O_4$ ), also known as minium, was used in primer paint as a red-orange pigment. It originally was a primary component of the paint on the Golden Gate Bridge (Witcher 2017). White lead ( $2PbCO_3 \cdot Pb(OH)_2$ ), also known as basic lead carbonate, is a white pigment that was extensively used. Lead compounds were mixed with linseed oil to create lead putty to seal wooden boats (Holmes 2012). Lead chromate ( $PbCrO_4$ ) is used as a yellow pigment in paint, and was a common additive to yellow highway striping paint (Post and Campbell 1980). While lead paint for homes was phased out in 1978, industrial lead paint is still available for some applications, and lead-based road paints continued to be used after 1978. Many commercial metal buildings and structures are painted in lead-based paints and have not been repainted.

Another large historical use of lead is the addition of ethyl lead compounds to gasoline to increase its octane rating. Even now, leaded gasoline use continues in some aviation fuels. Much of the lead in gasoline was emitted to the environment from the exhaust pipes of cars, and the signature of that elevated lead around roadways remains to this day. Historically, released lead from gasoline continues to run off from roadside soils as they erode.

Although lead use has been slowly phased out, some common uses remain. Lead shot, fishing sinkers, and tire weights are commonly used and are often lost to the environment. While lead tire weights were banned in California in 2010, they are still legal in much of the United States. The U.S. Environmental Protection Agency estimates that 1.6 million pounds of lead is released to the environment each year from lead tire weights (USEPA 2024). All these factors lead to lead runoff in modern times still being much higher in urban environments (Mahler et al 2006).

### 1.3.3.1 Lead Cables

In the complaint filed by the California Sportfishing Protection Alliance, it is alleged that there are approximately 7.8 miles of lead-clad telecommunication cable in the lake, with 3.3 lb of lead per foot of cable, for a total of 68 tons (61,688.6 kg) of lead. The complaint describes the cables as having two protective layers of bitumen-impregnated jute and a layer of 0.25-in.-thick steel rod wrapping. These outer layers encase the layer of lead that wraps the copper telephone cables at the core of the cables. I have observed the cables during a site visit, and observed the protective covering on the cables.

Other experts (Thomas 2024; Eiselstein 2024) have evaluated the environmental sampling data and the potential for release of lead from the cables: this analysis primarily focuses on the non-cable-related sources of lead to Lake Tahoe.

### 1.3.4 Environmental Chemistry of Lead

Lead is a generally insoluble element, forming minerals with phosphates, sulfates, carbonates, and sulfides (Lindsay 1979). It also adsorbs to iron, aluminum, and manganese oxide minerals, especially at neutral pH values (pH 5.5–8.5), reducing its concentration in solution (Kabata Pendias and Pendias 2001; Dzombak and Morel 1990). In most environmental systems, these sorbed phases are the primary form of lead in sediment. These sorbing minerals and organic matter are almost always associated with fine-grained materials, making lead and other sorbed metals relatively enriched in finer grained (clay and silt sized) sediment compared to sediment as a whole. Therefore, in most settings, finer grained sediments will generally have more lead in them than the sediment as a whole.

In anoxic (oxygen-deficient) sediments, lead binds with sulfide to form insoluble lead sulfide, which has a very low solubility. The formation of insoluble forms of lead has been shown to reduce the environmental bioavailability of lead to organisms in sediment (Casas and Crecelius 1994), in addition to impacting its movement in the environment.

Because of the insoluble nature of lead, in most lacustrine settings the largest mass of lead in a system is found in fine-grained solid phases, with only small amounts of lead being dissolved in the water.

### 1.3.5 Analytical Chemistry and Sampling

Dissolved lead is typically found at very low levels in waters (less than 1  $\mu\text{g}/\text{L}$ ), requiring low detection limits to adequately characterize its concentration. Because surface water and groundwater generally contain some solid particles, and solids contain much higher levels of lead, it is important to filter samples carefully (usually through a 0.45- $\mu\text{m}$  pore-size filter) to ensure that dissolved concentrations are measured (Nicholson 2007). This filtration must be performed in the field to ensure that lead does not precipitate during transport to the

laboratory for analysis. Some studies and applications require the analysis of all the lead in a sample, including the particulate lead. These samples are not filtered in the field and are usually preserved with acid in the field. For unfiltered samples, it is crucial to not artificially stir up additional particles from sediment that can result in samples that do not represent actual site conditions. Given these challenges, focusing on the specific design of studies and what is being measured is important in evaluating environmental lead data.

## 2 OPINIONS

My opinions regarding lead in Lake Tahoe are detailed below.

### 2.1 OPINION 1. LAKE TAHOE PROPERTIES FACILITATE LEAD DEPOSITION

#### 2.1.1 Opinion

Lake Tahoe is an alpine lake with circumneutral water, low suspended solids, and relatively little shallow littoral area along the lake shore. This setting does not favor retention of dissolved or suspended lead in the water column of the lake.

#### 2.1.2 Basis

The chemical and physical characteristics of Lake Tahoe create an environment that facilitates the removal of lead from the water column of the lake (Figure 4). The most important characteristic of the lake is its circumneutral pH. Measured lake pH ranges between 7.2 and 7.8 (Sierra Ecosystem Associates 2018; Haley & Aldrich 2024). At these pH levels, lead forms insoluble minerals (Lindsay 1979) and is strongly sorbed to clay minerals, iron, manganese, and aluminum oxide minerals (Dzombak and Morel 1990; Kabata Pendias and Pendias 2001).

Furthermore, the physical geometry of the lake with its narrow high-energy littoral zone allows for the settling of lead-bearing solids in the lake bottom. The lead attenuating characteristics are reflected in the low lead concentrations observed in the lake, where measured concentrations are typically below 0.1 µg/L (Chien et al 2019; Ramboll 2023; Haley & Aldrich 2024).

### 2.2 OPINION 2. ON AN ANNUAL BASIS, NATURAL SOURCES CONTRIBUTE HUNDREDS OF KILOGRAMS OF LEAD TO LAKE TAHOE WATER AND SEDIMENT

#### 2.2.1 Opinion

Lake Tahoe receives approximately 700 kg of lead loading annually from natural sources, including surface water runoff from minerals in rock and groundwater inflow.

#### 2.2.2 Basis

Natural lead loading to Lake Tahoe comes from runoff from minerals in rock and air deposition. Lake Tahoe sits in the midst of several mining districts and has several mines within its

watershed, indicating elevated lead concentration in the regional geology. Significant lead loads are expected from these sources and have been estimated from studies on the area.

Heyvaert et al. (2000) measured the total flux of lead to Lake Tahoe both before the area was extensively settled (pre-1850) and after 1980, based on the concentration and deposition rates of sediments in the lake. They found that approximately 700 kg of lead per year was deposited in the lake prior to settlement of the region. This result was calculated using the area of the sediments, the average sediment concentration in the pre-1850 sediments (11.7  $\mu\text{g}/\text{kg}$ ), and the average deposition rate of the sediments based on sediment age dating.

This result is consistent with the loading of sediments from surrounding rocks and minerals. USGS sampling of regional sediments in streams indicates that concentrations range up to 105  $\mu\text{g}/\text{kg}$  lead (USGS 2006).

Lead loading to the lake would also come from groundwater inflow and air deposition. Chien et al. (2019) estimated the loads from these sources in modern times, and overall, they are small relative to surface runoff sources (see Section 2.3.2).

The results of the work of Heyvaert et al (2000) show that Lake Tahoe receives hundreds of kilograms of lead loading each year from the natural conditions surrounding the lake, absent human industrial and urban influences.

## **2.3 OPINION 3. ON AN ANNUAL BASIS, ANTHROPOGENIC SOURCES CONTRIBUTE THOUSANDS OF KILOGRAMS OF LEAD TO LAKE TAHOE WATER AND SEDIMENT**

### **2.3.1 Opinion**

Anthropogenic sources contribute thousands of kilograms of lead each year to Lake Tahoe. These sources include urban runoff, historical aerial deposition from leaded gasoline use, and other lead uses in the urban and aquatic environment. Lead loading from these sources increased with the urban development around the lake, and they are a major contributor of lead in the lake. In addition, fishing, boating, and hunting activities are additional sources of lead releases in Lake Tahoe.

### **2.3.2 Basis**

The growing population, urbanization, and use of Lake Tahoe have contributed large amounts of lead to the water and sediments in the lake. It is well-documented that increasing metals loading to sediments has occurred with increasing urbanization of the area surrounding the lake (Mahler et al. 2006). The Lake Tahoe Basin has approximately 55,000 full time residents (Lake Tahoe Destination Stewardship Planning Team. 2023) and more than 9 million visitors

every year. In the 1960s through the 1980s, lead paint was commonly used in both housing and marine applications, leaded gasoline was used in automobiles, and lead metal was more common in building and construction hardware. In addition, many residents and visitors use the area for boating, fishing, and hunting. All of these uses have contributed to increased levels of lead in the water and sediments of the lake.

As a result of these anthropogenic sources, lead loading to the lake has increased by a factor of 14 compared to pre-1850 lead levels. This increase is due to both higher concentrations of lead entering the lake from urban development and from higher sedimentation rates. Heyvaert et al. (2000) calculated lead loading to the lake for surficial sediments. In modern sediments, they found 9,800 kg/year loaded to the lake, a 14-fold increase in lead loading to the lake compared to pre-industrial conditions. Modern lake sediments measured in this study had a mean concentration of 82.6  $\mu\text{g}/\text{kg}$  lead, compared to pre-1850 levels of 11.7  $\mu\text{g}/\text{kg}$ .

One line of evidence that shows the loading to the lake from surface runoff is stormwater data compiled by the California Department of Transportation (2019). These data show lead concentrations in stormwater runoff at levels far higher than background levels of lead in the lake, with concentrations up to 15  $\mu\text{g}/\text{L}$ . These stormwater concentrations are higher than any total water concentration in tributary streams or in the lake itself, that I have observed.

Increased loading to the lake during modern development is consistent with the observed water quality issues in the lake since the 1960s. The presence of fine sediment is a consistent problem because it reduces the clarity of the lake water (Simon 2008). This increased fine sediment load is primarily due to urban runoff and impacts to the Upper Truckee River Marsh from construction of the Tahoe Keys Marina, which allows increased sediment loading from the Upper Truckee River. As previously discussed, lead is generally enriched in fine sediment so that a greater fine-sediment load would also result in a greater lead load.

The sources of lead to the lake have also been evaluated for air deposition, groundwater inflow, and surface water inflow by Chien et al. (2019). They evaluated the amount of deposition of aerial particles to the lake in recent years, finding that 3.1 kg of lead per year was deposited in the lake from air deposition. In addition, they studied groundwater and surface water loading of dissolved lead to the lake. Their calculated groundwater loading of lead was between 12 and 12.8 kg/year (with the majority of this loading being through several preferential flow areas, including the region around Emerald Bay). The calculated flux of dissolved lead entering the lake was between 26.3 and 45.4 kg per year. Note that the total loading of Chien et al (2019) is an order of magnitude lower than the pre-1850 loading of Heyvaert et al (2000). This difference is likely a product of Chien focusing on dissolved surface water loading instead of the total load of lead in sediments and dissolved in water. However, the Chien measurement of aerial deposition is based on the collection of particulate lead deposited in the lake.

People fishing in Lake Tahoe itself likely contribute hundreds of kilograms of lead to lake sediments each year. Lake Tahoe visitor surveys can be combined with research on the rate of fishing tackle losses to estimate lead loading to the lake. In 2015, the U.S. Forest Service

developed a visitor use report for Lake Tahoe (U.S. Forest Service 2015). In that report, it estimates that 7.7 million persons visited national forests in the Lake Tahoe area. Of these visitors, 1.4 percent engaged in fishing, spending an average of 2.8 hours fishing, which would result in 303,000 total hours of fishing. Duerr (1999) found that anglers lost approximately two sinkers per hour of fishing. Sinker weights vary due to the type and use. They can range from 0.5 oz (14 g) sinkers for use along the shore (Mile High Fishing 2024) to up to 10-lb weights in deeper waters, to fish at depths of 75 ft (Mile High Fishing 2024). Fishing in the open waters of Lake Tahoe is often at depths greater than 30 ft (Richey 2009), necessitating heavier weights. Even if the typical sinker is 14 g (a 0.5-oz sinker), people fishing and losing sinkers at the rate measured by Duerr (1999) would result in 946 kg of lead loading to Lake Tahoe each year.

This loading is consistent with other studies that document tons of lead fishing tackle being lost to sediments each year in Canada, Sweden, and Great Britain (Grade et al. 2019).

The loss of fishing tackle is not the only source of lead from lake users. Historically, lead-based putty was the favored compound for sealing wooden boats (Holmes 2012), and lead-based paint was used on boats because of its durability and rust inhibition. While many of these products have been phased out, they were the favored compounds used on boats for many years and would have contributed to lead in sediment. Lake Tahoe contains the wrecks of many boats. The California Department of Parks and Recreation established an underwater Maritime Heritage diving trail in Emerald Bay that includes “recreational boats, launches and barges used on the lake in the early 20th century” (California State Parks 2024). These historical wrecks likely have lead paint and putty in their construction.

Also, any hunting activity in the basin using lead bullets or shot would result in additional lead loading to the lake. In their efforts to remove trash from the lake, the group Below the Blue has documented the collection of lead bullets from the lake bottom (Figure 5).

The data clearly demonstrate that there are abundant anthropogenic contributions to lead concentrations in Lake Tahoe sediments from the many human activities around the lake.

## **2.4 OPINION 4. LAKE TAHOE WATER HAS RELATIVELY LOW CONCENTRATIONS OF LEAD**

### **2.4.1 Opinion**

Despite the natural and anthropogenic inputs to the lake, the concentration of lead in Lake Tahoe waters is very low (less than 1  $\mu\text{g}/\text{L}$ ), and below all relevant water quality standards, as a result of the natural processes in the lake that remove lead from the water column.

## 2.4.2 Basis

Measurement of lead in Lake Tahoe waters shows that it has low concentrations of lead (<0.1 µg/L). These low concentrations are consistent with the high clarity of lake water and the low solubility of lead at circumneutral pH.

Several studies have clearly shown these low concentrations. The Chien et al. (2019) study reported that all lead concentrations in lake water samples were below 0.6 µg/kg. Studies by Ramboll (2023) and Haley & Aldrich (2024) were conducted in the vicinity of two telecommunication cables in the lake. In the Haley & Aldrich study, only 2 of the 16 samples collected for dissolved lead were above the method detection limit of the study, and all samples were below 0.1 µg/L. Similarly, the Ramboll study also showed low levels of dissolved lead, with only 4 of the 15 dissolved lead samples above the method detection limit for lead. The authors of the Ramboll and Haley & Aldrich studies concluded that the telecommunication cables in the lake were not adversely impacting water quality.

## 2.5 OPINION 5. LEAD IS PRIMARILY ASSOCIATED WITH FINE SEDIMENT IN LAKE TAHOE, RESULTING IN REMOVAL OF LEAD FROM LAKE TAHOE WATERS

### 2.5.1 Opinion

In the Lake Tahoe system, the vast majority of lead in the lake is bound in fine sediments. These sediments settle to the deep lake bottom and are removed from the water column.

### 2.5.2 Basis

Lead in Lake Tahoe is primarily associated with the fine sediment in the lake. Because of the low solubility of lead, the concentration of lead in sediment is higher than the concentration of lead in water. Lead in sediment measured by Heyvaert et al. (2000) found that central Lake Tahoe surface sediments had an average concentration of 82.6 µg/kg, 1,400 times higher than in filtered water samples (Chien et al. 2019). This relationship between fine-grained sediments and metal concentrations is well documented in many systems and has been shown to remove metals from solution (Nimick and Moore 1991).

Because of the association of metals with fine grained sediments, the settling of these sediments removes the lead from the water column and deposits the lead in lake sediments. As most of the lake sediments in Lake Tahoe are at a significant depth (more than 1,000 ft), this lead is removed from the surface water of the lake. These physical and chemical properties of Lake Tahoe allow it to maintain low levels of lead in the water column despite the loading of thousands of kilograms of lead per year to the lake from natural and anthropogenic

sources. The size of the lake and the settling of the lead-fixing sediment removes lead from the water column and deposits lead in the lake bottom.

## **2.6 OPINION 6. ANY LEAD LOADING TO LAKE TAHOE FROM TELECOM CABLES WOULD BE NEGLIGIBLE COMPARED WITH LOADING FROM OTHER SOURCES OF LEAD**

### **2.6.1 Opinion**

Based on the assessment of the impact of lead-bearing telecom cables on water and sediment quality in Lake Tahoe, which was conducted by other experts, any lead loading from cables would be negligible compared with loading from other sources of lead to Lake Tahoe.

### **2.6.2 Basis**

The loading of lead to Lake Tahoe from both natural and anthropogenic sources is thousands of kilograms per year. Other experts (Tiffany Thomas, Ph.D. and Larry Eiselstein, Ph.D.) have evaluated the stability of the telecommunication cables in the lake, and have found:

1. The concentration of lead in water surrounding the cables is extremely low and consistent with background levels of lead in Lake Tahoe.
2. There are few areas along the length of the cables where lead is exposed to water, due to damage to the protective covering of the cables.
3. The metallic lead present in cables is stable, and a passivating layer forms on the surface of exposed lead, limiting the release of lead.
4. Lead that may dissolve from the metallic lead in cables will re-adsorb to the cable materials, resulting in no observable release of lead from the cables.

Given the stability of cables in the lake and the fact that very little lead is exposed in the lake because the cables are generally intact, it is difficult to measure any lead release to the lake, as the water surrounding the cables has essentially the same concentration of lead as other lake water. In comparison with the thousands of kilograms entering the lake annually through natural and urban runoff, the hundreds of kilograms entering the lake annually through losses due to fishing tackle, and the additional flux of lead entering the lake water from sunken boats and other debris, the contribution of lead from the cables would be negligible.

### 3 CONCLUSION

Lake Tahoe receives thousands of kilograms of lead loading each year from natural sources, surface runoff, and from users of the lake. Despite this loading, the physical and chemical nature of Lake Tahoe allows for the removal of this lead through precipitation and adsorption reactions, resulting in the deposition of this lead in deep lake sediments. This mechanism is supported by the levels of lead observed in lake water compared with the levels of lead observed in deep sediments.

## 4 QUALIFICATIONS

### 4.1 QUALIFICATIONS

Dr. Andrew Nicholson is a geochemist with 25 years of experience assessing the environmental impacts and chemical fate at industrial facilities and mining sites. Dr. Nicholson has conducted analyses of the source and mobility of metals and other chemicals in sediment, soil, and groundwater. His work has included extensive analysis of the behavior of acids, metals, radionuclides, and organic compounds in the environment at mines and in chemical manufacturing, petroleum production, and industrial settings. Dr. Nicholson has authored numerous articles and book chapters, including the chapter on groundwater chemistry in the most recent edition of *Groundwater and Wells*, the standard reference for the water well industry. He has served as an expert witness on a variety of matters, including determining the sources and distribution of metals at mining sites. His resume is included in Appendix A.

### 4.2 COMPENSATION

Dr. Nicholson is compensated at a rate of \$330 per hour. He has no financial stake in the matter at hand.

### 4.3 PRIOR TESTIMONY

Dr. Nicholson has not testified or been deposed in the past 4 years.

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*Lead in the Lake Tahoe Environment*

Andrew Nicholson, Ph.D.

September 9, 2024

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## **Figures**

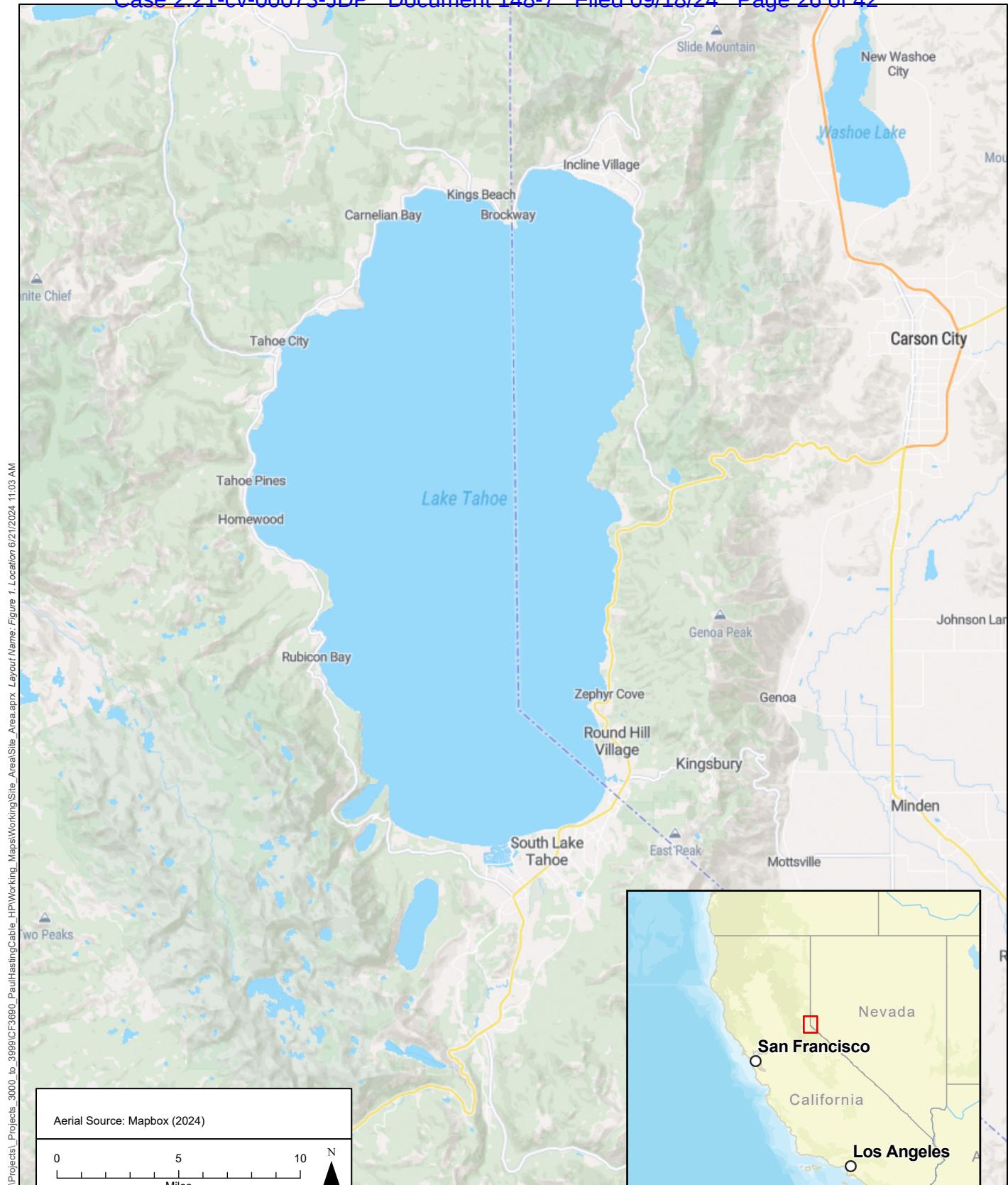
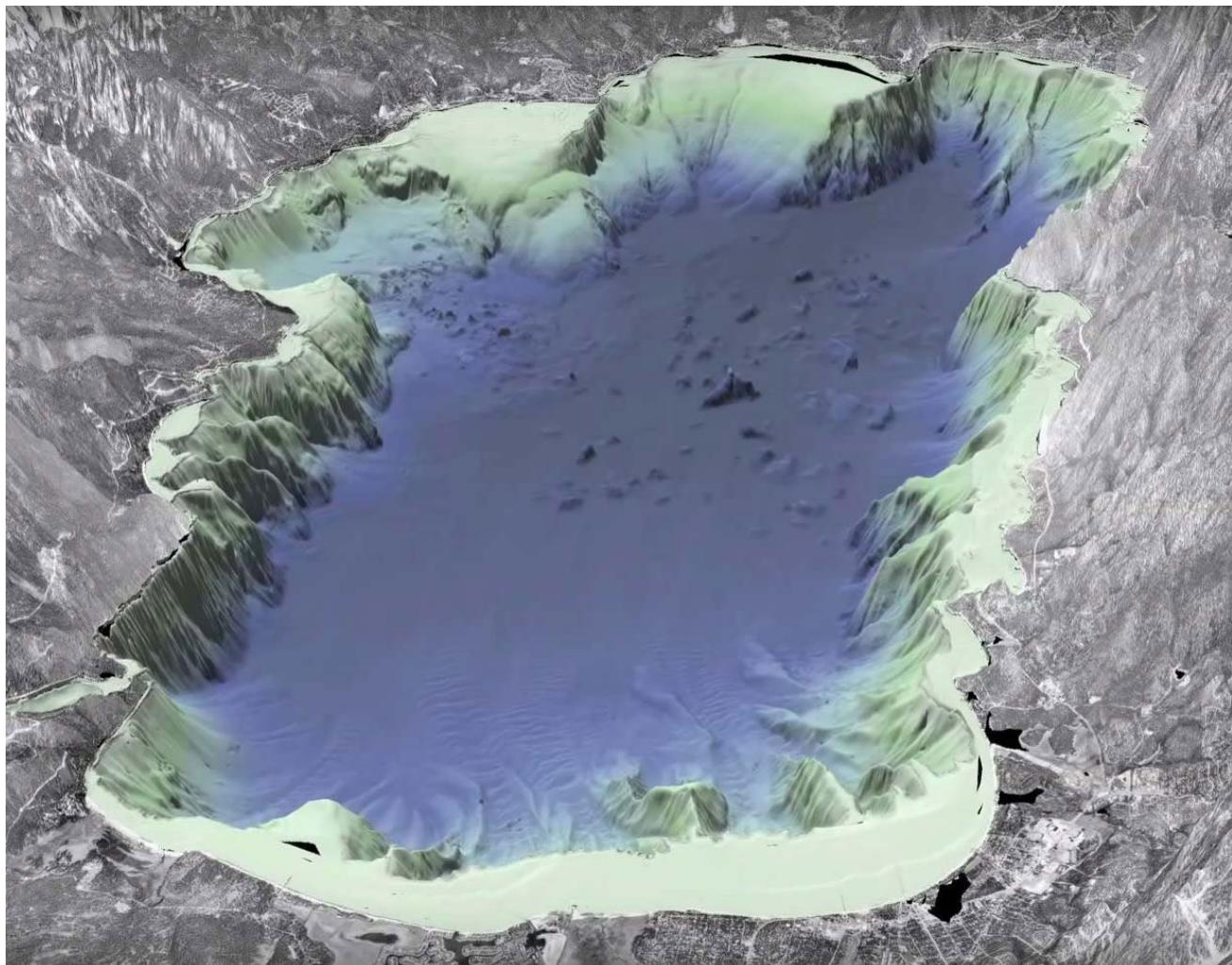
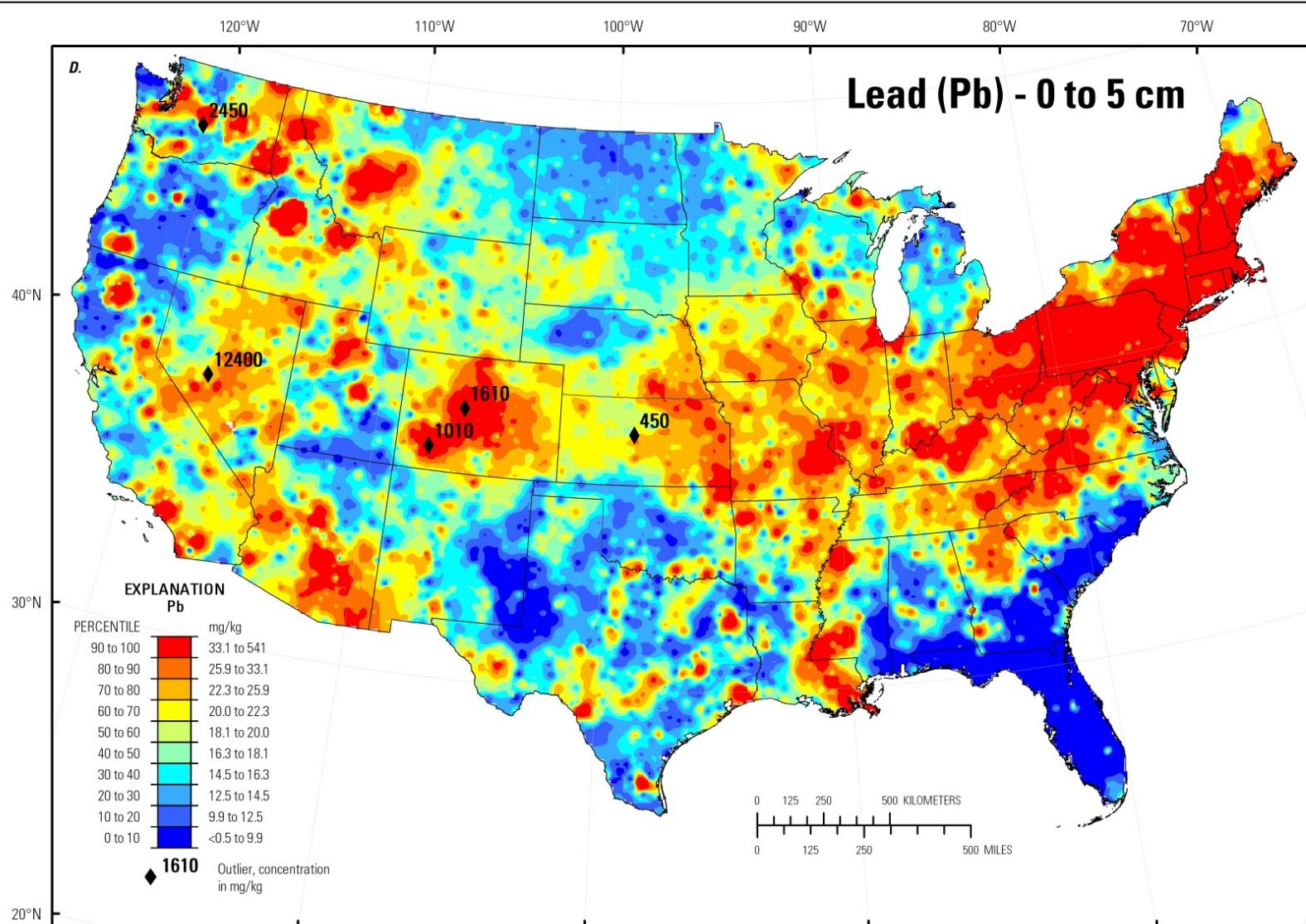


Figure 1.  
Map of the Lake Tahoe Area

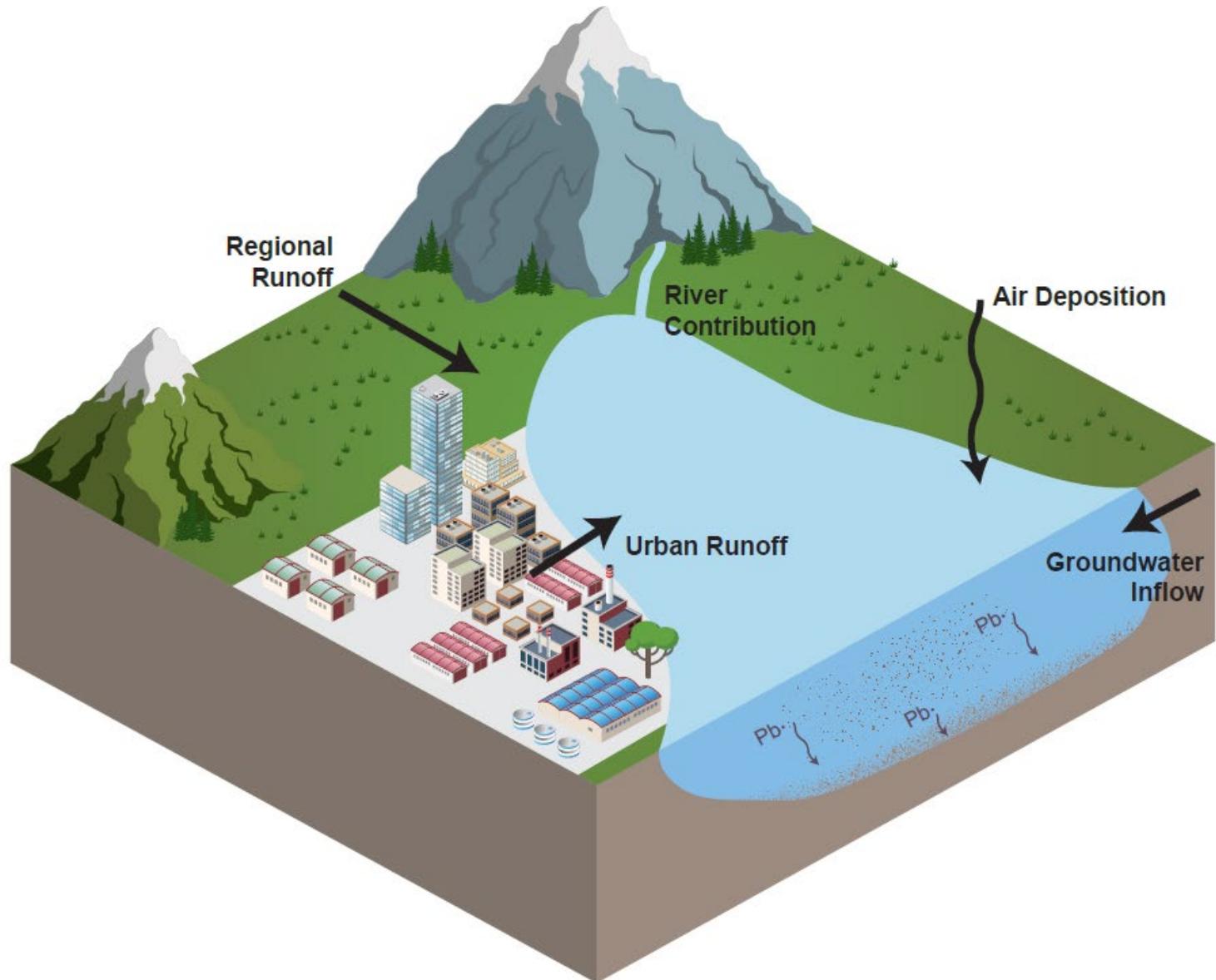


Source: USGS (2024)



Base map from U.S. Geological Survey digital data  
Lambert Conformal Conic projection  
Standard parallels 33°N and 45°N  
Central Meridian 96°W  
Datum NAD 1983

Source: USGS (2019)



**Figure 4.**  
Loading and Cycling of Lead in Lake Tahoe



Source: Below the Blue (2023)



**Figure 5.**  
Garbage Collected from Lake Tahoe Showing the Presence of Lead Bullets.

## **Appendix A**

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Resume of Andrew Nicholson, Ph.D.



# Andrew Nicholson, Ph.D.

## Senior Science Advisor

(720) 465-3330

Boulder, CO

[anicholson@integral-corp.com](mailto:anicholson@integral-corp.com)

### Education & Credentials

Ph.D., Geochemistry, Colorado School of Mines, Golden, Colorado, 1993

B.S., Geology, Michigan State University, East Lansing, Michigan, 1985

### Continuing Education

Hazardous Waste Operations and Emergency Response 40-Hour Certification (1991-2009)

Hazardous Waste Operations Management and Supervisor 8 Hour Certification (1991)

First Aid and CPR Certified (2004)

### Professional Affiliations

Phi Beta Kappa

Phi Kappa Phi

Dr. Andrew Nicholson is a geochemist with 32 years of experience assessing the environmental impacts and chemical fate at industrial facilities and mining sites. Dr. Nicholson has conducted analyses of the source and mobility of petroleum hydrocarbons, metals, PCBs, and other chemicals in sediment, soil, and groundwater. His work has included extensive analysis of the behavior of acids, metals, radionuclides, and organic compounds in the environment at mines and in chemical manufacturing, petroleum production, and industrial settings. Dr. Nicholson has authored numerous articles and book chapters, including the chapter on groundwater chemistry in the most recent edition of *Groundwater and Welts*, the standard reference for the water well industry. He has served as an expert witness on a variety of matters, including determining the sources of petroleum hydrocarbons at manufactured gas plant and petroleum sites.

### Relevant Experience

#### LITIGATION SUPPORT

**Confidential Lead Recycling Sites, California**— Assessed the sources of lead in soils in a neighborhood surrounding a lead recycling facility. Potential sources included the facility itself, leaded gasoline uses, lead paint use, and other urban lead sources.

**Confidential Sediment Site, Texas**—Determined the contribution of an oil refinery to wetlands impacted by chemical production operations. Work included evaluating fingerprints of petroleum contamination and comparing those fingerprints of the production of other chemical compounds.

**Confidential Gas Station Site, New York** — Determined the age of MTBE releases from a service station in New York for a cost recovery case. Testified in state court on results of findings.

**Confidential Petroleum Site Litigation, New York** — Evaluated the contribution of petroleum contaminants from a group of terminals to a larger CERCLA site in New York State. Evaluated the composition of the petroleum products handled onsite and applied forensic techniques to compare these products to the larger sediment site and other sources to the site including publicly owned treatment works outfalls, urban runoff, chemical manufacturing, and manufactured gas plant discharges.

**Confidential Gas Station Site, New Jersey** — Provided technical support for a mediation on an insurance cost recovery case for a gas station. Determined the age of petroleum contamination



in the ground and demonstrated the sources of contamination from specific service station operations.

**United States v. Apex Oil, Hartford, Illinois** — Testified as an expert witness in federal court in a cost recovery case evaluating the sources of hydrocarbons based on lead, gasoline additive, and PAH data.

**United States v. WSDOT, Tacoma, Washington** — Expert witness in a cost recovery case evaluating the contribution of PAHs from a former manufactured gas plant site to estuary sediments through stormwater sewers.

**PCB, PAH, and Metals Source Allocation in Harbor Sediments, Great Lakes, U.S.** — Developed and implemented a program to determine the quantitative loading of contaminants to a harbor in the Great Lakes. This work showed the importance of two previously unidentified sources of contaminants, and that the chemical fingerprints of PCBs, PAHs, and metal composition were consistent with large amounts of sediment contamination coming from these sources.

**Confidential Site, Virginia** — Evaluated the mobility, bioavailability, and transport of historical zinc discharges to a river from a rayon manufacturing facility in support of a natural resource damage evaluation.

**Chemical Fingerprinting of Petroleum Hydrocarbons, Texas** — Developed a fingerprint of petroleum hydrocarbons that quantitatively distinguished petroleum condensate from leaded and unleaded gasoline related to leaks from a gas-condensate well and surrounding pipelines.

**Fate and Transport Analysis, Superfund Site, Rocky Mountain Region** — Conducted a program to determine sources and ages of petroleum hydrocarbons, PCBs, and creosote in the subsurface at a Rocky Mountain Superfund site.

**Petroleum Refinery and Distribution Terminal, New York** — Developed an allocation of free product underlying a refinery and a petroleum distribution terminal.

**Evaluation of Arsenic Contamination, New Jersey** — Developed procedures to allocate arsenic contamination between a pesticide manufacturing facility and a pyrite ore processing facility in estuarine sediments. Methods included lead isotope, sulfur isotopes, and electron microprobe analyses.

**Fate and Transport Analysis for Petroleum Facilities, Texas** — Developed novel tools to quantitatively apportion hydrocarbon plume composition among two gasoline handling facilities and a leaking petroleum pipeline.

**Evaluation of Concrete Degradation, Boston, Massachusetts** — Investigated geochemical controls on cement stability in marine sediments and fill soils to determine the mechanism of concrete degradation in the Fort Point Channel in Boston Harbor in support of litigation regarding liability related to a building's foundation failure. Implemented a field sampling and analysis program that included drilling, vibracoring, and analysis of samples at three separate laboratories. This work discovered a previously undocumented mechanism of concrete



degradation due to the presence of high levels of sulfate and sewage, and low reactive iron content in the surrounding sediments.

**Former Solvent Recycling Facility, Southeastern U.S.** — Developed methods to evaluate the age of mixed chlorinated solvent and hydrocarbon contamination at a former solvent recycling facility in the southeastern U.S. in support of cost allocation litigation. Methods used included careful characterization of the redox state of local groundwater, evaluation of the bacterial activity at the site, and hindcasting the original composition of the spill based on the abundance of chlorinated degradation products in the groundwater.

**Insurance Litigation, Antifreeze Recycling Process, Massachusetts** — Investigated the causes of silica precipitation in an antifreeze recycling process, using wet chemical, x-ray diffraction, electron microprobe, and geochemical modeling techniques in support of insurance litigation on product failure. Results of this work indicated that metal contaminants in the used antifreeze cause the precipitation of sodium silicate corrosion inhibitors.

**Lone Tree EIS Litigation, Valmy, Nevada** — Technical expert supporting litigation on an environmental impact statement (EIS) in Nevada. Issues involved included establishing appropriate baseline conditions for the EIS, pit-lake chemistry, and ecological effects, and evaluating the potential degradation of groundwater.

**Arsenic Evaluation for a Pesticide Manufacturing Facility, Minnesota** — Developed a technique to predict arsenic concentration in soils from atmospheric dust deposition from a pesticide manufacturing facility in support of ongoing toxic tort litigation.

**Geochemical Support for Dispute Resolution, Rocky Mountain Region** — Provided geochemical support for cost allocation in an alternative dispute resolution hearing at a copper deposit in the Rocky Mountain West. Reviewed geochemical data, ore deposit geology, and site geochemistry to develop lines of technical questioning during the hearing.

**Mercury Toxicity Analysis, New York** — Used the geochemical model MINTEQA2 to evaluate the speciation and toxicity of mercury in the outfall of a mercury chlor-alkali plant into a harbor for a confidential client involved in insurance litigation.

## GEOCHEMISTRY

**Sour Gas Evaluations, Kemmerer, Wyoming** — Evaluated the compositional difference of hydrocarbons produced in sweet and sour gas fields in thrust belt gas fields of southwestern Wyoming.

**Landfill Closure, Minnesota** — Evaluated background metals concentrations and the sources of cadmium, selenium, and lead in groundwater beneath a hazardous waste landfill in Minnesota.

**Pipeline Leak, Alabama** — Evaluated the sources of hydrocarbons surrounding a breached petroleum products pipeline that had a major leak and fire.

**Methylene Chloride in Groundwater, Rochester, New York** — Determined the sources of releases of methylene chloride at an active pharmaceutical manufacturing facility. Distinguished releases



that had been remediated during prior operations from releases that occurred during current operations.

**Multimedia Fate and Transport Analysis, Pascagoula, Mississippi** — Technical lead in the analysis of the mobility of multiple compounds in groundwater in 10 different areas of concern at a large oil refinery. Responsible for the design and implementation of the hydrologic and geochemical characterization, the ongoing monitoring plan, and interpretation of the data in all of the areas of concern (AOCs). Communicated this work on a regular basis to EPA Region 4, the lead regulator on the site. The work resulted in monitored natural attenuation being a selected remedy at eight of the AOCs. The analysis led to the refinery receiving the CA 550 Environmental Indicator (groundwater migration under control) and the CA 750 Environmental Indicator (construction complete).

**Evaluation of Groundwater Discharge to an Industrial Estuary, Pascagoula, Mississippi** — Technical lead evaluating the geochemistry and hydrology of groundwater discharging to the local estuary, and potential remedial approaches to the issue. Supervised the development of a detailed groundwater model to evaluate remedial alternatives including natural attenuation, flow-through reactive walls and groundwater collection trenches. Presented the results of these studies to EPA Region 4 staff for approval and for certification of the CA 550 and 750 RCRA Environmental Indicators.

**Whitehorse Refinery, Whitehorse, Yukon Territories** — Evaluated the chemical fingerprint of different hydrocarbon sources over a period of 50 years at a former refinery and barge dock.

**Evaluation of Sediment Fate and Transport, Minnesota** — Evaluated the observed changes of dioxin, furan, PAH, and metals chemistry in sediment at a Superfund site in the upper Midwest. Evaluated chemical fingerprints of these compounds and determined that the apparent increase in contaminant concentrations was simply due to differences in EPA-mandated sampling techniques and not due to new releases to the system.

**Belleville Landfill, Belleville, Michigan** — Conducted an evaluation of the mobility, toxicity, and bioavailability of PCBs, PAHs, and cyanide in the stream sediments receiving outfall from a leachate treatment facility for a hazardous waste landfill in Michigan after a catastrophic release. Work was conducted under intense regulatory scrutiny, with the state agencies collecting splits of all samples. Collected all samples and negotiated the ultimate solution with State of Michigan regulatory agencies.

**Former Chemical Manufacturing Facility, New Jersey** — Evaluated the mobility of mercury, lead, zinc, copper, manganese, and arsenic in groundwater, surface water, and estuarine sediments at a former mercury chemical manufacturing facility in New Jersey.

**Refinery Closure, Kenai, Alaska** — Developed a quantitative rate of petroleum degradation at a former oil refinery site based on the organic, carbon isotopic, and alkalinity data in the plume.

**Geochemical Investigation at a Former Landfill Site, Maryland** — Conducted a geochemical investigation of manganese and vinyl chloride geochemistry and mobility at a former landfill site. Results of the study indicated that vinyl chloride and manganese were being attenuated in the aquifer, and that these compounds would not migrate off site.



**High Production Volume Test Plan Review** — Evaluated the chemical toxicity and composition of petroleum coke for EPA's High Production Volume Chemical Program. Work included developing structure-activity relationships based on the PAH chemistry of the coke to minimize testing costs.

**Tributyltin Consortium** — Developed a sensitivity analysis, the MAM-PEC model, to predict sediment loading and toxicity of tributyltin to sediments.

**Terra PAH Peer Review** — Served on a peer review panel evaluating a statistical model to assess the toxicity of complex mixtures of PAH compounds.

**Arsenic and Chromium Mobility Analysis, Wilmington, Massachusetts** — Used the geochemical model MINTEQA2 to identify aquifer zones and to evaluate remediation scenarios for a remedial investigation and feasibility study at a Massachusetts tannery. Calculations demonstrated the effects of organic complexation on chromium solubility, the controls of arsenic methylation, and the effects of sulfide mineral precipitation on iron, copper, and lead concentrations in groundwater.

**Geochemical Analysis Course Development, Golden, Colorado** — Developed new laboratory and field exercises for a graduate-level analytical geochemistry course, including exercises in organic extraction, sampling of rocks and soil, and analysis of acid mine drainage.

**Chemistry Department Safety Analysis, Golden, Colorado** — Assisted in the development of a new safety policy for the Colorado School of Mines Department of Chemistry as the graduate student member of the departmental safety committee. Work included safety inspections, hazardous materials response, and development of a waste disposal plan.

**Kelly Air Force Base Metals Mobility, San Antonio, Texas** — Designed and managed a study to evaluate partitioning of priority pollutants between soil and groundwater at Kelly Air Force Base. This work was the first attempt on record to establish inorganic cleanup standards under risk reduction rules promulgated by the State of Texas.

## MINING

**Red Dog Mine, Alaska** — Evaluated the metal concentration impacts of emissions from mine operations on surrounding soils, vegetation, and sediment. Also evaluated the mobility of metals in the tundra environment, including reviewing metal bioavailability, assessing metal mobility during mine closure options, and evaluating the effectiveness of ongoing monitoring programs.

**Soil Lead Background Concentration Evaluation, Jefferson County, Missouri** — Designed studies to evaluate natural background levels of lead and other compounds in soils in the Jefferson County Superfund Site, Missouri.

**Mine Waste Evaluation, Montana** — Conducted an investigation evaluating the sources of mine wastes at a metals mine tailings deposit for source allocation litigation. Supervised the collection of more than 600 samples in a soil boring program, designed a database, and developed new analytical methods to determine mine waste sources. This study integrated new information on ore deposit chemistry, the use history of the area by ore processors and railroads, the fate and transport of metals in soils, geotechnical properties of mine wastes, historical ore processing techniques, and sediment transport to determine sources of wastes.



**Gold Mine Closure, South Dakota** — Evaluated the potential environmental liabilities at closure of an operating gold mine that had been in continuous production for more than 125 years, including those related to mercury leaching from historical stamp-mill tailings, pit lake water quality, waste rock seepage water quality, and future underground mine discharge water quality.

**Evaluation of Arsenic Transport, Southern California** — Evaluated the mobility and speciation of arsenic in soils and groundwater at the site of a former brass refinery in Southern California. Assessed the mobility of arsenic in slag from the site using electron microprobe and laboratory bench testing methods. Based on the soil and groundwater data, developed a conceptual site model of arsenic transport at the site.

**Mercury Evaluation at a Gold Mine Site, Nevada** — Evaluated the mobility of high-level mercury concentrations (e.g., > 1 mg/L) in groundwater associated with a cyanide heap leach facility at a gold mine in Nevada.

**Evaluation of Acid Consumption in a Copper Leaching Process, Arizona** — Developed experimental and modeling methods to predict the neutralization capacity of silicate minerals at a proposed copper heap leach SX/EW copper processing facility based on laboratory experiments and the geochemical reaction path model EQ3/6.

**Metals Bioavailability to Wildlife, Texas** — Assessed the bioavailability of metals to wildlife at a former petroleum refining facility in Texas. The results of this study were used to develop ecologically protective soil screening levels.

**Arsenic Groundwater Source Evaluation, Texas** — Evaluated soils and groundwater to predict the sources of arsenic in groundwater at a former petroleum refinery in Texas. The results of the study showed that arsenic was derived from the mobilization of natural sources due to past petroleum releases, not due to arsenic releases at the site.

**Batu Hijau Mine Permitting, Sumbawa, Indonesia** — Conducted and managed a multidisciplinary investigation for a proposed Indonesian copper-gold mine to predict the effects of mining on local water resources and determine the water quality in the resulting pit lake. The coupled hydrologic- geochemical model incorporated hydraulic inflows, geochemical source terms, diffusive mixing, oxic and anoxic geochemical reactions, and site-specific geology based on the geologic block model. Results of this study were presented to Indonesian regulators for the ANDOL (Indonesian EIS), joint venture partners, and financial institutions in the due diligence process.

**Climax Mine, Climax, Colorado** — Evaluated molybdenum, manganese, and fluorine chemistry in surface water and sediments downgradient of a molybdenum mine in Colorado in support of permit negotiations with EPA and the State of Colorado.

**Lone Tree Mine Permitting, Valmy, Nevada** — Managed a multidisciplinary pit-lake water quality study for a Carlin-type open-pit mine in Nevada in support of an EIS. Data collected in this study also were applied to evaluate the weathering of waste rock at the mine. Results of the pit-lake study were used to model the transport of arsenic, fluoride, and antimony downgradient of the pit lake.



**Pit Lake Water Quality Evaluations, Nevada** — Primary geochemist involved in the prediction of pit lake water quality in more than 20 pit lakes. Fifteen of these studies were technical support of EIS documents at mines in Nevada.

**Wood-Treatment Facility Closures, Texas and Missouri** — Designed and implemented programs that achieved clean closure without site remediation at two chromated copper arsenate wood treating facilities in Texas and Missouri. These cleanup standards evaluated protection of both groundwater and human health, based on bioavailability, metal speciation, and metal mobility in soil.

**Evaluation of Arsenic in Groundwater, Lone Tree Mine, Nevada** — Managed and implemented a geochemical evaluation to determine the causes of increased arsenic in dewatering well discharge at a mine in Nevada. The study involved evaluation of regional and dewatering well chemistry data, exploration assay data, site mineralogy, and regional geology and hydrology to determine the cause of the increase. Represented the mine in negotiations with regulators in hearings on the mine's discharge permit violations.

**Mineralogic Controls on Bioavailability, Butte, Montana** — Used the reaction path modeling package EQ3/EQ6 to understand the evolution and weathering of lead oxide minerals and galena in soils and mine waste at a Montana Superfund site. Model paragenesis matched the observed paragenesis of lead minerals in the soil. These data will be used to determine cleanup levels at this site.

**Pit Lake Water Quality Evaluation, Nevada** — Used the equilibrium geochemical models MINTEQA2 and PHREEQE to simulate the mixing of acid-bearing waters with carbonate groundwater. Bench-scale experiments and modeling demonstrated that adsorption to iron hydroxide controls the dissolved concentrations of arsenic, lead, cadmium, zinc, and copper in mine drainage.

**Application of Red Mud By-products in Groundwater Remediation, Miami, Arizona** — Evaluated the chemical and physical properties of a red mud, a by-product of aluminum ore processing, as an amendment to neutralize acid and metals in a groundwater plume formed from copper leaching operations.

**Review of Site Groundwater Chemistry, Confidential Location** — Reviewed site soil and groundwater chemistry data for due diligence related to the purchase of South American bauxite mine. Work included evaluating general options to manage the disposal and reclamation of red mud and other wastes at the facility.

**Study of Mercury Speciation at an Industrial Site, New Jersey** — Designed and implemented a study of mercury speciation in soils at an industrial site in New Jersey. Utilized microprobe, sequential extraction, and visual mineralogical analyses to characterize the distribution of mercury species in soils. The data were then used in conjunction with in vitro assays of soils to develop mercury bioavailability factors for the site. This work is the first acceptance of a site-specific mercury bioavailability standard by the State of New Jersey.



**Pinal Creek Aquifer Studies, Miami, Arizona** — Evaluated the geochemical controls of the mobility of an acidic plume in an alluvial aquifer downgradient from several copper leaching operations.

**Water Quality Effects of an Iron Mine, Northern Michigan** — Implemented a study of acid rock drainage and the impact of iron precipitates on fish for a natural resource damages lawsuit at a closed iron mine in northern Michigan.

**Evaluation of Mercury Speciation at a Soil Incineration Facility, New Jersey** — Evaluated the speciation of low-level (<2 ppm) mercury in soils at a soil incineration facility at a site primarily contaminated with organic solvents. This work focused on evaluating how the speciation of mercury in soils affects mercury air emissions from the facility.

**Soil Treatment Study, Mississippi** — Used the reaction path modeling package EQ3/EQ6 to determine optimum concentrations of phosphate soil amendments needed to reduce the solubility and bioavailability of lead at a harbor's ore loading facility.

**Evaluation of Metal Leaching, Northern Rocky Mountains** — Determined the rate of arsenic, copper, lead, and zinc leaching from soil, slag, and mine tailings at a Superfund site in the northern Rocky Mountains using column leaching experiments on intact soil columns in support of natural resource damage litigation. The model PRZM was used to predict basin-wide metal loading to groundwater for an ecological risk assessment.

## Publications

Nordstrom, D.K., and A. Nicholson (eds). 2017. *Geochemical Modeling for Mine Site Characterization and Remediation*. Volume 4. Society for Mining and Mineral Exploration, Englewood, CO.

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## Presentations/Posters

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Greer, B., A Nicholson, S. Helgen, and S. Kosinski. 2013. Incorporating wall rock runoff into pit lake water quality modeling in the arid western United States. International Mine Water Association Annual Meeting, Golden, CO.

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## Invited Participant, Expert Panels, And Workshops

Co-instructed one-day course on environmental forensics for CLE credit and New Jersey LSRP credentials, 2018, 2019.

## Expert Testimony

### Court Testimony

- Strong Oil Company, Inc. v. Zurich American Insurance Company. Supreme Court of the State of New York, County of Suffolk.

### Deposition Experience

- Georgia-Pacific Consumer Products LP v. NCR Corporation. U.S. District Court for the Western District of Michigan (two depositions).
- Wild Earth Guardians v. IRG Bayaud et al. U.S. District Court for Colorado.
- NL Industries, Inc. v. ACF Industries, et al. U.S. District Court for Western District of New York.



- 2134 Western, Inc v Texaco, Inc. Superior Court of the State of Washington in and for the County of King.

